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ON THE STRATIGRAPHIC POSITION AND AGE OF THE JUDITH RIVER FORMATION

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PART III

THE PALEOBOTANICAL EVIDENCE

We have as yet no fully diagnostic flora for the Judith River beds, the plants from them being few in number and confined to two localities, one of which is in reality not positively placed stratigraphically. This meager collection, therefore, is by itself inconclusive. That fossil plants will be found later on is undoubtedly true, as indications of their presence have been noted, but they are evidently not abundant in the formation, careful search on our flying trip having proved entirely unsuccessful. In this connection it may be said that plant remains are similarly infrequent also in the Lance formation and in the Edmonton or "Lower Laramie" of the Canadians. The plants described from Willow Creek by Knowlton¹ from the beds referred to the Judith River by Stanton and Hatcher² are undoubtedly of Belly River age and do *not* come from the Judith River formation.

In 1908 fossil plants were collected by members of the U.S. Geological Survey from beds supposed by them to be of Judith River age near the Macklin Coal Company's mine on the Big Sandy in Montana. This locality is about 12 miles northeast of the Big Bend of the Missouri River below Fort Benton, and between 30 and 35 miles northwest of Judith Landing on the Missouri River near the east end of the Bearpaw Mountains. The list of plants as identified by Dr. Knowlton is as follows:

Viburnum perplexum Ward.
Plantanus nobilis Newberry.
Populus sp. (large leaf).

¹ *Bull. U.S. Geol. Surv., No. 257*, pp. 129-55.

² *Ibid.*, pp. 56-58.

Populus cuneata Newberry.
Populus glandulifera Heer.
Berchemia multinervis Al. Br.
Viburnum sp.
Sapindus grandifolius Ward.
Taxodium distichum miocenum Heer.

These are of undoubted Fort Union age, but as the named species are common to both the Upper and Lower Fort Union (Lance) formations, it is impossible, without knowing the exact stratigraphic relations, to say which of the two they represent. The probabilities are that they are from the Lower and are, therefore, from the Lance, that is, that they are really from the Judith River (not Belly River) beds, in accordance with the belief of the collectors; and they are likely to have come from the upper part of this series. However, at the present time it is impossible to make any very positive statement regarding them.

The second locality is on Cow Creek, where Dr. Stanton found many leaves of *Trapa(?) microphylla* about 30 feet above the base of the Judith River beds. This species has a wide distribution in the Fort Union formation, occurring in both the Upper and the Lower Fort Union beds, having been found abundantly by Professor L. F. Ward at Burns ranch on the Yellowstone below Glendive and at many other localities and by other collectors in the Lance formation in Converse County, Wyo. It is also found in the Canadian "Lower Laramie" which, as we regard it, is the equivalent of the Lance formation and of the Judith River beds. The type of *Trapa(?) microphylla* was described by Lesquerreux from the Montana formation of Point of Rocks, but, as Knowlton¹ has indicated, it is questionable whether the species from the Montana and from the Fort Union and underlying beds are all one and the same.

In regard to the plants of the Lower Laramie (or Judith River series in Canada), concerning which Dawson² made the statement that "the flora of the Belly River closely resembles that of the Lower Laramie," it is to be urged that comparison of the two lists shows that the resemblance between the floras is, after all, not very

¹ *Bull. U.S. Geol. Surv.*, No. 163, 1900, p. 63; *ibid.*, No. 257, 1905, p. 145.

² *Trans. Roy. Soc. Canada*, III, sec. IV (1885), p. 20.

striking. Besides, as Dawson¹ himself adds, "the few species are scarcely sufficient to afford a basis for definite conclusions." The list for the lower division of Dawson's Laramie contains eight species, of which six are common to both Upper and Lower. Two of the species, *Onoclea sensibilis* and *Sapindus affinis*, are characteristic of the Fort Union in both of its divisions on the American side of the line. As to the Belly River list, it does not seem to be complete, *Pistia corrugata*, a characteristic Montana flora not being included. Adding this to the list, we have ten species, two of which, according to Knowlton, should be dropped. Only two of those remaining seem to be common to both Belly River and Lower Laramie, and this small proportion certainly cannot be said to establish a striking resemblance between the two floras. Regarding the others, Knowlton says:²

As to the affinities of the other named species, it may be mentioned that *Nelumbo dawsoni* is very closely allied to my *N. intermedia* from Point of Rocks, Wyo., while the other two species (*Populus latidentata* and *Acer saskatchewanse*) are not figured, nor are they described with sufficient fullness to permit of satisfactory comparison with other forms.

Stanton³ was probably correct when he said:

I suspect that in Canada two distinct formations, separated by marine beds, have been confused under the term Belly River series, and that a large part of the fauna, and possibly also of the flora, was collected from the upper horizon, which included the Laramie and possibly even later beds.

It seems equally true that in this country the same formations have been confused. Our knowledge of the flora, of the Lance formation, has been considerably enlarged in the past few years.⁴ The Belly River flora, however, is in need of critical study, and until that can be done we must content ourselves with the confident prediction that the difference between them will be greater than now appears; and that when a flora for the Judith River beds is developed, its affinities will be with the Lance rather than with the Belly River flora indicated above.

¹ *Trans. Roy. Soc. Canada*, IV, sec. IV (1883), pp. 32, 33.

² *Bull. U.S. Geol. Surv.*, No. 257, 1905, p. 154; see also *ibid.*, No. 163, 1900, pp. 9, 10.

³ *Ibid.*, No. 163, 1900, p. 11.

⁴ See Knowlton *Proc. Wash. Acad. Sci.*, XI (1909), 179-238.

THE INVERTEBRATE EVIDENCE

According to Dr. T. W. Stanton:¹ "As the Judith River is essentially a non-marine formation, strictly speaking its fauna should not be made to include the marine species" which in the one occurrence noted by him, he supposes to have been "brought into the Judith River area by a local temporary invasion of pure marine waters." There is also in the formation "a brackish-water fauna of wide geographic distribution confined to thin beds in its upper and lower portions of the formation."

It is apparently the consensus of opinion among invertebrate paleontologists that fresh-water faunas *per se* are of little or no value in the accurate determination of the age of beds in which they occur. Fresh-water beds are found at a number of horizons between the Devonian and the present time. In the Devonian, shells resembling the modern *Unio* have been found and *Unios* of similar types have also been collected from the Triassic and Jurassic. Writing of the fresh-water beds at the top of the Jurassic Dr. Stanton² says:

Its invertebrate fauna consists of several species of *Unio*, *Vivipara*, *Planorbis*, etc., all of modern fresh-water types, which do not assist in discriminating between Jurassic and Cretaceous. *Unios* have been found in several horizons in the Cretaceous, and when we get as high as the Ceratops beds (Lance formation) many, if not all of the specific types found there, may be found also among living species.

Whitfield³ describing the *Unios* from the Hell Creek region of Montana says of fourteen species that they are "so nearly like the living species that it would do but little violence to specific features to say they were the same."

Writing of the non-marine faunas found in the Ceratops beds of Converse County, Wyo., Stanton says:⁴

It must be admitted that in themselves, without any reference to stratigraphic occurrence or local geologic history, these fossils could not be depended

¹ *Bull. U.S. Geol. Surv.*, No. 257, pp. 119 f.

² *Jour. Geol.*, XVII (1909), 414.

³ *Bull. Amer. Mus. Nat. Hist.*, XXIII (1907), 624.

⁴ "The Age and Stratigraphic Relations of the 'Ceratops Beds' of Wyoming and Montana," *Proc. Wash. Acad. Sci.*, XI (1909), 288.

upon for the discrimination of horizons within the Cretaceous nor for distinguishing between Cretaceous and Tertiary.

Fresh-water invertebrates therefore cannot be depended upon as time-markers in geologic investigations; still it is true as Stanton further says:¹

When the investigation is confined to a single region and when the geographic and stratigraphic range of non-marine species has been determined their evidence is useful and important.

Therefore, from the viewpoint of the present writer the stratigraphic position of the Judith River beds is the same as that of the Lance formation, or the lower portion of it; a comparison of their fresh-water faunas is interesting and instructive, because it corroborates to a considerable extent the more conclusive evidence presented by the vertebrates.²

THE VERTEBRATE EVIDENCE

Hayden in his early explorations in 1855 collected in the Judith River basin, not only marine invertebrates from the Fox Hills sandstones underlying the fresh-water fossiliferous Judith River beds, but also obtained from the latter, vertebrate remains which constitute the first horned dinosaurs of the *Ceratopsia* ever collected in this country. These, and other specimens from near Long Lake, N. D., in what is now called the Lance formation, were studied by Dr. Joseph Leidy, resulting in the establishment by him of four genera and species of dinosaurs.³ Later, his descriptions were elaborated and published⁴ with illustrations. Although in his first article, Leidy thought that the Judith River formation might be of Wealden age, in his second publication he was inclined to consider the formation as "a part of the great Cretaceous series of Nebraska, though [he says] we should not feel surprised if future explorations should determine it to be of Tertiary age."⁵ In the

¹ *Proc. Wash. Acad. Sci.*, XI (1909), 285.

² Stanton, *op. cit.*, p. 286, refers to the widespread association of some of the species in association with the dinosaur fauna, stating that a "large proportion of them, including some of the more striking and characteristic forms, occur at Black Buttes."

³ *Proc. Acad. Nat. Sci., Phila.*, VIII (1856), 72-73.

⁴ *Trans. Amer. Phil. Soc.*, XI, N.S., Philadelphia, 1860, pp. 138-54.

⁵ *Ibid.*, p. 140.

opinion of the writer this prophecy of Leidy's made in 1860 is today being verified.

Professor E. D. Cope, with the assistance of C. H. Sternberg and John C. Isaacs, spent a part of the summer of 1876 in the exploration of the Judith River basin between Fort Benton and Armell's Creek, 130 to 150 miles farther down the Missouri River,¹ and secured a considerable number of dinosaurs, referable to several new genera and species, and fragmentary remains afterward determined to be *Ceratopsia*. Hatcher spent a couple of months of the summer of 1888 in the Judith River badlands with what he calls very indifferent success,² and in the summer of 1903, with T. W. Stanton, spent two more months "in the field study of the Judith River and associated formations of northern and central Montana and adjacent areas of Canada."³

In the interval between 1855 and the present time (1912) explorations have been carried on over widely separated areas in the Rocky Mountain region of the United States, resulting in the discovery and development of many localities from which vertebrate remains (many in a fragmentary condition) have been collected, the beds in which they occurred being post-Laramie formations. The most characteristic species appear to be those of genera belonging to the *Ceratopsia*, one of the first described species coming from the beds at Black Buttes, Wyo.

Besides the localities in Converse County, Wyo., collected by Hatcher, Williston, Baur, and Case, and the Denver and Arapahoe areas of Colorado by Cannon, Cross, and Eldridge, and the Hell Creek region by Barnum Brown, many others in the Rocky Mountain region have yielded vertebrate remains, mostly, however, in a fragmentary condition. Thus *Ceratopsia* have been found near the North Platte River in Wyoming about 40 miles north of Fort Steele by Hatcher in 1888, and from near the same locality by Knowlton and Peale in 1910, here also by Hatcher, on the east side of the Big Horn Mountains 40 miles south of Buffalo, Wyo.; on the west side of the Big Horn River between Fort Custer and Custer Sta-

¹ *Bull. U.S. Geol. and Geog. Surv. Terr.*, III (1877), 565-97.

² *Monograph U.S. Geol. Surv.*, XLIX (1907), 7.

³ *Bull. U.S. Geol. Surv.*, No. 257, 1905, p. 9.

tion, Mont.; and north of Musselshell, Mont. In addition to the Hell Creek specimens listed by Barnum Brown he collected *Triceratops* and *trachodont dinosaurs* south and southeast of the Yellowstone River in Montana, Wyoming, and the Dakotas. Throughout this general area also the various parties of the U.S. Geological Survey engaged in tracing the distribution of the coal formations during the past six years have brought in numerous vertebrate specimens of similar character, showing their wide distribution in the Lance formation.

As noted on a preceding page, Hayden was unable to detect any material difference between the deposits of the Judith basin and those of the Fort Union, especially of the portion lying at the base of the latter in the Missouri River region extending to the eastward. Similarly all the earlier paleontological workers could not make any separation based on the vertebrate remains found in them and did not separate the Judith River beds faunally from the beds, that, at Long Lake, N.D., and along the Yellowstone River and several other localities, lie immediately below the undisputed Fort Union. Cope also in his work in northeastern Colorado recognized that he was dealing there with beds identical with those of the upper Missouri River country, especially the reptile-bearing portion of the Fort Union.¹ As the area of exploration in the west widened, and collections, fragmentary as most of them were, increased, and admittedly insufficient and fragmentary as is the material from the Judith River basin, the more evident became the remarkable resemblance between the faunas from the beds now referred to the Lance formation and those of the Judith River beds. Undoubtedly this would have been still more evident had there not been a strong effort to differentiate them, due to a misapprehension as to the supposedly vastly older age of the Judith beds as deduced from supposed stratigraphic evidence. The probability of the Judith River beds being of post-Laramie age on account of the stratigraphic position and the contained vertebrate remains is referred to by Cross.²

¹ *U.S. Geol. and Geog. Surv. of Terr. for 1873, 1874*, pp. 429, 430.

² *Monograph U.S. Geol. Surv.*, XXVII, 239.

Williston¹ notes a "startling resemblance" between the Wyoming Laramie [Lance Creek] fauna and that of the Judith River and Belly River series. Of course, if they are equivalent to each other, as we claim, this resemblance is not so startling. Williston, however, is not alone in mentioning this resemblance. Hatcher² himself says:

When considered in its entirety, the vertebrate fauna of these beds [Judith River beds] is remarkably similar to, although distinctly more primitive than, that of the Laramie [Lance formation]. Almost or quite all of the Laramie [Lance formation] types of vertebrates are present, though as a rule they are represented by smaller and more primitive forms.

However, it remained for Dr. O. P. Hay³ fully to bring out this resemblance and demonstrate the equivalence of the Judith River and Lance formations. Having demonstrated, as he supposes, that there was a nearly complete change in the fauna and a considerable change in the flora between the time of the deposition of the Lance Creek beds and those known as Puerco and Fort Union, he says:

I will endeavor to show that the fauna of the former beds is closely related to that of the Judith River. This close relationship of the two faunas has been recognized, it may be truthfully said, by all paleontologists who have given attention to the subject.

In his discussion of the relationship of the two faunas Dr. Hay begins with the fishes and follows with the tailed amphibians. He quotes Hatcher, who says eight species of fishes have been described from the Judith River deposits. Of these Hatcher says:

While they give an indication of the character of some of the fishes that inhabited the waters of this region in Judith River times, they are at present known from such insufficient material as to render them of little value for purposes of correlation, as is abundantly evidenced by the apparent similarity existing between the fish remains known from these beds and those from the Laramie [Lance formation]. This similarity is so striking that some paleontologists have been led largely from such evidence to *correlate the Judith River*

¹ *Science*, N.S., XVI (1902), 952.

² *Bull. U.S. Geol. Surv.*, No. 257, 1905, p. 107.

³ Reprint from the *Proc. Ind. Acad. Sci.*, Twenty-fifth Anniversary Meeting, 1909, pp. 1-27.

*beds with the Laramie [Lance], disregarding the more important evidence afforded by the dinosaurian fauna and the stratigraphy.*¹

The italics above are the writer's. Here again we run up against the stratigraphic misapprehension already alluded to. As to the dinosaurian evidence, as we shall presently see, its trend is the same as that afforded by the fishes. It is axiomatic that only the species common to any two or more formations are of any use in correlating them. *Lepidotus occidentalis* Leidy, described in 1856 from the Judith River beds, has been found by Williston² in the Lance formation of Converse County, Wyo., and by Barnum Brown in the Lance formation in the Hell Creek region. With this *Lepidotus* Williston found also another species, *Myledaphus bipartitus*, named by Cope from the Judith River beds. This seems to be a ray according to Hay,³ who says: "The rays are almost wholly inhabitants of salt water; hence the persistence of this Judith River fresh-water form is somewhat remarkable." Another species of *Diphyodus*, a genus founded on a jaw fragment from a Canadian locality, is said by Hatcher to be common both in the Judith River beds of Montana and in the Laramie [Lance] deposits of Converse County, Wyo., and a species of the same genus was found by Barnum Brown in the Hell Creek beds. The tailed amphibians, which Hay says are at all times rare fossils, are all referable to the genus *Scapherpeton*, and five species were described by Cope from fragmentary material obtained in the Judith basin of Montana. Williston found one species in the Lance formation and Brown reported a species from the Hell Creek beds. Hatcher considers the batrachia of the Judith River beds of no special importance in determining the age of the deposits or in correlating them with other formations. Dr. Hay, however, referring to them says:⁴

While it is true that these fishes and amphibians are mostly represented by fragmentary remains, these remains are usually characteristic and capable of accurate comparison. That *Myledaphus* should reappear after an interval allowing the deposition of 1,000 feet of marine strata, and probably some hundreds of feet of fresh-water strata, is remarkable enough; but that it should reappear in company with its old companions, the rare *Diphyodus* and *Scapher-*

¹ Bull. U.S. Geol. Surv., No. 257, p. 67.

² Bull. Amer. Mus. Nat. Hist., XXIII (1907), 842.

³ Hay, *op. cit.*, p. 20.

⁴ Hay, *op. cit.*, pp. 20, 21.

peton, not to mention the more highly developed fauna yet to be discussed, is very striking. Had there occurred at both levels only some pebbles of three peculiar forms or compositions, instead of the three genera, the conclusion would have been inevitable that there was some particular connection between the two formations.

When we realize that there is no interval between the Judith River beds and the Lance formation, allowing the deposition of thousands of feet of marine strata, we see that there is no remarkable reappearance of *Myledaphus* and its companions, but that they have simply coexisted in beds of the same age at different localities. As to *Champsosaurus* and the Crocodilia, it will serve our purpose here just to quote Dr. Hay, who says:

Coming next to the reptiles, it may first be noted that species of *Champsosaurus* occur in the Judith River beds, in the Lance Creek beds, in those of the Hell Creek region, and in the Puerco. It is probable that the species vary from one formation to the other. The same statement can probably be made regarding the crocodiles. *These genera, common to all three of the formations under discussion, may be left out of consideration; although it must not be overlooked that, none the less, they aid in binding together the formations in which they are found.* As to the crocodiles, it may be mentioned that Williston recognized, in teeth and scutes found in the Lance Creek beds, Leidy's *Crocodylus humilis*, originally described from the Judith River region. From the Judith River beds of Alberta, Lambe described *Leidyosuchus canadensis*. Mr. C. W. Gilmore will soon describe a second species of the genus, collected last summer in the Lance Creek beds of Converse County, Wyo.

The sentence italicized by the writer in the above quotation is the one specially pertinent to the present discussion.

As regards the turtles which have been especially studied by Dr. Hay, he says:

My study of the fossil turtles indicates that the species of these animals rarely pass from one epoch to another. If they have ever done so, they passed from the Judith River into the Lance Creek epoch. There are five or six species of Judith River turtles which are represented in the Lance Creek and Hell Creek beds by turtles of identical or very closely related species. Most of these are marked by such peculiar sculpture that they are easily recognized and some of them likewise are represented by excellent materials.

Dr. F. H. Knowlton has recently shown conclusively¹ that, of the sixteen species of turtles accredited by Hatcher to the Judith

¹ Knowlton, *Proc. Wash. Acad. Sci.*, XII (1911), 51-65.

River beds, only nine are actually found in the Judith basin of Montana. Four of these are types and of these, only two are confined to the Judith beds. The other seven are common to both the Judith and Lance formations which, in view of what Dr. Hay has written, is good proof of their identity in age.

The most abundant and conspicuous reptiles in both the Judith River and the Lance formations are the dinosaurs, and practically half of those listed by Hatcher are common to both formations. Writing of these dinosaurs Dr. Hay says:¹

Five families of these, belonging to four super-families and to two suborders, are represented in the Judith River epoch, and each of these families reappears in the Lance Creek epoch. Furthermore, many of the genera are common to the two formations and it is believed that the same is true of a considerable number of species.

Hatcher in his summary in the consideration of the dinosaurs² says that "they of all the vertebrates of these beds [Judith River] afford the best basis for a comparison of the fauna of these deposits with that of the Laramie [Lance] above (?) and the Jurassic below." He says the great group of Sauropoda which formed a conspicuous feature at the close of the Jurassic and the beginning of the Cretaceous is entirely wanting, and that the Stegosauria, which formed a striking feature among the Jurassic dinosaurs, have almost or quite disappeared, being entirely replaced by the quadrupedal Ceratopsidae and the bipedal Trachidontidae. "No unmistakable representative of the Stegosauria is certainly known from the Judith River beds. *Palaeoscincus*, referred to this suborder chiefly on the evidence of teeth alone, may or may not pertain to the Stegosauria, while *Stereocephalus* appears to have been founded on material belonging in part to the Crocodilia and in part to the Dinosauria." On the following page Hatcher states that these Dinosauria are not distinguishable from remains from the Laramie [Lance] at present referred to the Ceratopsia. Whether or not *Palaeoscincus costatus*, described from the Judith River badlands by Leidy in 1856, is represented in the Lance formation by numerous teeth³ cannot be positively stated. The genus is represented

¹ *Op. cit.*, p. 23.

² *Bull. U.S. Geol. Surv.*, No. 257, pp. 101-3.

³ Hatcher, *op. cit.*, pp. 83, 88; Hay, *op. cit.*, p. 23.

in the Hell Creek region and in Converse County, Wyo. Hatcher¹ says:

The Trachodontidae had already attained to considerable diversity in Judith River times. Indeed they appear to have been more abundant as regards both numbers of individuals and genera and species than they were in the Laramie [Lance]. Judging from the rather meager material at hand for comparison, they were, however, somewhat less specialized.

As to the Theropods, he says that so little is at present actually known from either the Laramie [Lance] or the Judith River beds "that it is quite impossible to make anything like an adequate comparison between them. The group, however, is represented in both formations by quite similar forms, though differing perhaps both generically and specifically." This statement appears to be little more than an assumption, inasmuch as about half the identified species are common to both formations. Although as Hay says,² much has yet to be learned of the Ceratopsia, especially of the Judith River forms, the knowledge of which is still somewhat vague, most of the remains from that region being of incomplete skulls. However, the interest in them has been so great that they have been studied with extraordinary care. This fact doubtless influenced Hatcher's statement: "It is in the Ceratopsidae more than in any other group that we are at present able to contrast the Judith River and Laramie [Lance] forms."³ Hatcher's conclusion based on this comparison is as follows:

The primitive nature of the Judith River Ceratopsidae as compared with the Laramie [Lance] is especially seen in the *smaller size of the individuals, the less perfectly developed armature of the skull, and the imperfectly developed parietal crest.*

The italics are Hatcher's.⁴ This supposed contrast in the forms from the two formations is reiterated by Hatcher throughout his paper and in his monograph on the Ceratopsia edited by R. S. Lull and published by the Geological Survey.⁵ Osborn, in making the same contrast, comparing especially the nasal and supraorbital horns mainly of the species of *Monoclonius* and *Ceratops* (found in

¹ Hatcher, *op. cit.*, p. 102.

³ Hatcher, *op. cit.*, p. 102.

² Hay, *op. cit.*, p. 24.

⁴ *Ibid.*, pp. 102, 103.

⁵ *Monograph U.S. Geol. Surv.*, XLIX (1907).

the Judith River beds) which he says are very similar if not generically identical, says:¹

It will be observed that five of these species [of *Monoclonius* and *Ceratops*] are known to possess large nasal and small supraorbital horns. This stage of horn evolution *may* be contemporaneous and independent of that on the southern Laramie [Lance] dinosaurs in which the nasal horns are invariably smaller than the frontal horns, but coupled with the smaller size and open temporal *fossæ* it would appear to be more primitive.

The italics above are Osborn's and they seem to be justified by the fact that we do find species of *Ceratops* and of *Triceratops* coexisting in the same beds as in the Arapahoe formation of Colorado which, although of post-Laramie age, is probably older than the Lance formation. Dr. Hay's remarks² on the *Ceratopsia* are interesting in this connection. He says:

Apparently nine species are known from the Judith River deposits of Montana and British America; and about fifteen species are credited to the Lance Creek beds of Wyoming, and to the Arapahoe and the Denver, of Colorado. Hatcher and Lull conclude that those of the Judith epoch are somewhat more primitive than those of the beds higher up, being somewhat smaller, with a less completely developed nuchal frill, with the nasal horn relatively larger and the supraorbital horns relatively smaller than in the younger forms. It is, however, to be noted that the nasal horn of *Ceratops*, of the Judith River epoch, is not yet certainly known. For the most part the genera are based on the characters mentioned above. They may have the importance assigned to them, but they do not indicate radical differences. Such differences might easily have arisen during an interval of moderate duration.

The supposed primitive nature of the *Ceratopsidae* of the Judith River basin of Montana as compared with those of the Lance formation of Wyoming and the supposed stratigraphic positions of the beds are apparently the main reliances of the advocates for the earlier age of the former and have led to considerable confusion in their consideration by different writers. Mr. R. S. Lull³ has thus been led astray in his phylogeny of the *Ceratopsia*, which is based apparently more upon supposed geological position, than upon the phylogenetic characters. He is evidently misled because

¹ *Contributions to Canadian Paleontology*, III (1902), 20.

² Hay, *op. cit.*, p. 24.

³ Advance print *Proc. 7th I. Z. C.*, Boston, 1902, Cambridge, 1910, p. 2.

of his belief that two thousand feet of marine shales and sandstone of Bearpaw and Fox Hills age intervene between the Judith River beds and the Laramie [Lance] formation. These deposits, in his opinion, represent a period of subsidence during which the advancing sea drove the land animals to the west and north. He says:¹

Of these creatures which link the Judith River and Laramie [Lance] faunas, no remains have thus far been found so that we have no record of the evolution which must have occurred during the period of subsidence. At the close of the Fox Hills epoch, conditions much like those of the Judith River times again prevailed, and the horned dinosaurs, among other forms, sought their ancestral haunts. Four genera of Laramie [Lance] Ceratopsia are known, ranging themselves into two races or phyla which underwent a parallel evolution.

In this connection my friend Mr. J. W. Gidley of the U.S. National Museum has kindly prepared for me the following statement:

Regarding the validity of the Ceratopsia phyla as worked out by R. S. Lull, it seems to me to be highly conjectural and not founded on a basis of valid reasoning. While it may be conceded that Ceratops is in general more primitive genus than Triceratops, it is highly improbable that, having already developed a far greater nasal horn than in any species of the latter genus, this horn should have become atrophied while the brow horns were being developed to become the principal ones. Only that Ceratops is supposed to have come from much older beds, it would be just as reasonable to suppose that the reverse might have been the case, and so far as the horns alone are concerned Ceratops might just as well have been the descendant of a Triceratops form. It seems far more reasonable to suppose that, whether contemporaneous or separated by a long time interval, Ceratops and Triceratops represent two quite distinct phyla, developing horns along different lines.

As already intimated, the principal cause of confusion is to be found in erroneous ideas as to the stratigraphic position of the beds from which the collections were made. As a matter of fact, however, the time has not yet arrived when the phyla can be correctly constructed. Not only is the material already in hand too fragmentary, but it is too meager in the number of forms supposedly identified, nor are there sufficient specimens of each species to determine the distinctions due to individual variation or to differences in sex or age. When we find that Ceratops and Triceratops (one of which is supposed to be ancestral to the other) were con-

¹ *Ibid.*, p. 4.

temporaneous in Arapahoe time, and it is stated that the affinities of *Monoclonius* are with *Triceratops* and that *Ceratops montanus* is the ancestor of *Torosaurus*, while there is a possibility that *Monoclonius* may yet be identified with *Ceratops*, the present unavoidable confusion becomes noticeably evident.

Rearranging Lull's table of the "Geological Sequence of the Ceratopsia"¹ to accord with the views set forth in this paper, we have the following:

Formations	Localities	Species
Lance.....	Hell Creek, Mont.....	{ Triceratops sp. Triceratops brevicornus Triceratops serratus
Lance.....	Converse Co., Wyo.....	{ Trosaurus latus Trosaurus gladius Diceratops hatcheri Triceratops brevicornus Triceratops flabellatus Triceratops calicornis Triceratops sulcatus Triceratops prorsus Triceratops horridus Triceratops elatus Triceratops obtusus
Lance.....	Near Judith, Mont.....	{ Ceratops montanus Ceratops paucidens Ceratops recurvicornis Monoclonius sphenocerus Monoclonius crassus
Denver.....	Denver, Colo.....	{ Triceratops alticornis Triceratops horridus
Arapahoe.....	Near Denver, Colo.....	{ Triceratops alticornis Triceratops galeus Ceratops montanus*
Post-Laramie.....	Black Buttes, Wyo.....	Agathaumus sylvestris
Laramie.....	Black Buttes, Wyo.....	No Ceratopsia
Fox Hills.....	Black Buttes, Wyo.....	No Ceratopsia
Pierre.....	Black Buttes, Wyo.....	No Ceratopsia

* The type specimen of *Ceratops montanus* is in the collection of the U.S. National Museum. As to the specimen from Colorado, Professor Lull thinks "it must be a case of mistaken identity." This, in the writer's opinion, is due to the fact that the Judith River beds and those of the Lance formation are mistakenly supposed to be separated by thousands of feet of beds.

The principal differences between this table and Lull's is the taking-away of the Lance formation from the Laramie; the inter-

¹ Lull, *op. cit.*, p. 184.

polation of the true Laramie between the Fox Hills and the Black Buttes beds, which are referred by us to the post-Laramie; and the placing of the Arapahoe and Denver below the Lance, reversing the position given them by Lull and the reference also of the Judith River beds to the Lance. This arrangement appears to me not only the true one but far better, as it ties the species together in a more logical manner. It will not be necessary to conclude as Lull has that the "identification of *Ceratops montanus* seems hardly possible, as *Ceratops montanus* is a Judith River type and is vastly older than the Arapahoe." Although the Arapahoe and Denver lie at the bottom of the series and the Hell Creek beds nearer the middle or at the top of the Lance formation, we do not yet know their exact equivalency, but that they are not separated by thousands of feet of beds can confidently be stated. Mr. Cross, long ago, pointed out "the fact that the Judith River strata may perhaps represent the Arapahoe or some other post-Laramie formation."¹

Eliminating from Hatcher's list of Judith River vertebrates (which includes no mammals in the type region) all the species which are duplicated under other names and all which come from beds not of Judith age or that occur outside the typical area (the Judith basin of Montana), his list is reduced to 33. Of these we find that 22 occur also in strata referred to the Lance formation. These species are tabulated below. Besides the Converse County, Wyo., and Hell Creek, Mont., lists, others might be given showing that Judith River species occur in other parts of Montana as well as in northeastern Colorado, but the lists given here are deemed sufficient to prove the identity of the beds.

Writing in 1902 (and the list was not so great then as now) on the identity of genera and species not only between these beds but including also the Belly River of Canada, Williston says:²

It would seem almost incredible that so many of these should have persisted unchanged through the long interval represented by so many thousand feet of Fox Hills deposits, to say nothing of those of the Fort Pierre. I doubt if a parallel can be found elsewhere in vertebrate paleontology. It is true that many of these forms from both the Judith River and the Laramie [Lance]

¹ *Monograph U.S. Geol. Surv.*, XXVII (1896), 239.

² *Science*, N.S., XVI (December 12, 1902), 953.

are known only from fragmentary remains and that future researches may show specific differences in some of them, but the resemblance in any event is marvelous.

This resemblance is no longer marvelous, when we know that in both cases we are talking of beds of the same age.

JUDITH RIVER FORMATION		LANCE FORMATION
Judith River Basin, Montana	Converse County, Wyoming	Hell Creek, Montana
Lepidotus occidentalis	Lepidotus occidentalis	Lepidotus occidentalis
Myledaphus bipartitus	Myledaphus bipartitus	
Accipenser albertensis	Accipenser albertensis	
Diphyodus longirostris	Diphyodus longirostris	Diphyodus sp.?
Scapherpeton tectum	Scapherpeton tectum	Scapherpeton tectum
Ischyrotherium, cf. antiquum	Ischyrotherium, cf. antiquum	
Trionyx foveatus	Trionyx foveatus	Trionyx foveatus
Adocus lineolatus	Adocus lineolatus	Adocus lineolatus
Compsemys obscurus	Compsemys obscurus	Compsemys obscurus
Compsemys victus	Compsemys victus	Compsemys victus
Champsosaurus	Champsosaurus humilis	Champsemys
Crocodylus humilis	Crocodylus humilis	Crocodylus sp.
Troodon formosus	Troodon formosus	
Deinodon horridus	Deinodon horridus	
Aublysodon mirandus	Aublysodon mirandus	
Paronychodon lacustris	Paronychodon lacustris	
Zaphalis abradus	Zaphalis abradus	
Deinodon explanatus	Deinodon explanatus	
Deinodon cristatus	Deinodon cristatus	
Deinodon hazenianus	Deinodon hazenianus	
Ornithomimus altus		Ornithomimus altus
Palaeoscincus costatus	Palaeoscincus costatus	Palaeoscincus sp.
Trachodon mirabilis	Trachodon mirabilis*	Trachodon sp.

* Hatcher, *Annals of the Carnegie Museum*, I, No. 3, p. 382.

In what has been written above the endeavor has been to prove from the words of the vertebrate paleontologists themselves the identity of the Judith River and Lance formations. Knocking from beneath the structure so elaborately reared the weak and ineffective stratigraphic props, the entire edifice must fall. Either the beds are identical in age, or vertebrate paleontology has no place in stratigraphic geology, and *non geologia sine paleontologia* becomes *non paleontologia sine geologia*. That they are, however, of the same age is the irresistible conclusion to which we come. Whether they are of Cretaceous or Tertiary age is beside the question at this place, although the views and opinions of the writer as to their early Eocene Tertiary age have been expressed in another part of this paper.

SUMMARY AND CONCLUSIONS

The Judith River formation was named and considered by Dr. F. V. Hayden to be of Tertiary age and, from that time (1855) to 1903, every geologist who studied the beds coincided in the main with his views. A list of these geologists who studied the beds in the field is as follows: F. B. Meek, E. D. Cope, C. A. White, Walter H. Weed, L. F. Ward, George M. Dawson, G. B. Grinnell, Ed. S. Dana, and T. W. Stanton. Not until 1903 was there any question as to their position nor much discussion as to their age, except by the vertebrate paleontologists. In this year after a study in the folded and faulted region surrounding the Bearpaw Mountains in Montana, Stanton and Hatcher traced the outcrops noted near Havre on the northeast side of the mountains up Milk River, across the international boundary to Pakowki Coulee and correctly correlated the beds exposed at Havre with the Belly River beds already identified on Milk River by the Canadian geologists, but they incorrectly correlated these beds with the Judith River formation exposed mainly between the Bearpaw Mountains and the Missouri River, confusing the two formations as the Canadian geologist had previously done. These formations were the Judith River beds overlying the Pierre and the Belly River series lying below the Pierre shales. This confusion as to position, as noted, had occurred also in the Canadian outcrops and was straightened out by McConnell and Tyrrell. Stanton and Hatcher were led into the same error also on Fish Creek south of the Musselshell River and on Willow Creek north of the same river in Montana, as was very evident to us when we revisited this area in 1911. Our first conclusion, therefore, is that the Judith River beds and the Belly River series, although both of fresh-water origin and lithologically very similar, are entirely distinct from each other, occupying stratigraphical positions separated by 1,000 feet or more of marine sandstones and shales.

The sandstones and sandy shales immediately underlying the typical Judith River beds are of marine origin and contain a fauna which Dr. Stanton says has long been considered a "typical Fox Hills" fauna. In addition to this fauna we found *Halymenites major*, a characteristic plant of the Fox Hills formation, throughout

the Rocky Mountain region. Further, a comparison of the Fox Hills fauna from the Judith River Basin with those of other sections in the Rocky Mountains, particularly with those from Colorado where the most complete Fox Hills sections is found, shows that only 4 of the 18 species occurring in the Judith River section are not found elsewhere. These Fox Hills beds in the Judith River basin were named Claggett by Dr. Stanton, but apparently this is only another name for the Fox Hills formation as developed in the disturbed portions of the Judith basin. Our second conclusion, therefore, is that the Fox Hills formation, with its characteristic fauna and flora, immediately and unconformably underlies the Judith River beds and that it rests conformably upon exposures of characteristic Pierre shales throughout the Judith basin.

It has further been shown that the Judith River beds occupy the identical stratigraphical position of the Lance formation. Both rest unconformably upon Fox Hills sandstones. Possibly we have in the Judith River beds the equivalent of only the lowest portions of the Lance formation. It has also been shown that out of 33 species of vertebrates occurring in the Judith River beds, 23 are common to both the Judith River and the Lance formations. The invertebrates of both are mainly fresh-water forms which closely resemble each other in the two formations, and the plants of both, so far as they are known, suggest a Lance or Fort Union rather than the Belly River age. Undoubtedly there are areas on all sides of the Bearpaw Mountains in which, when we get beyond the area of disturbance due to the uplift, continuous sections will show below the Pierre shales, the Belly River series with characteristic floras, and above, the Judith River beds with floras referable to the Lance and Fort Union formations. There are indications that the conditions are like those found on the Canadian side of the international boundary. We have no hesitation in stating the third conclusion, viz., that the Judith River formation is the representative if not the exact equivalent of the whole or of some, perhaps lower, portion of the Lance formation and that the latter name should be replaced on the ground of priority of use by the name Judith River formation.

We have also seen that the Belly River series is always overlain by the Pierre shales not only in the Canadian sections but also

south of the international boundary, especially in Fish Creek south of the Musselshell River, and at Willow Creek 12 miles north of Musselshell. By no stretch of the imagination, can the beds below the Belly River series be taken to represent the Pierre shales, either lithologically or paleobotanically. In both the United States and Canada, the affinities of the flora are with the Dakota and not with the Montana. The faunas, in Canada especially, show a mingling of Niobrara and Pierre forms, and although there is a bare possibility that the upper part of the Belly River series may be of basal Montana age, it is more than likely that there is here simply a mingling of forms as at the base of the Fox Hills formation, where there is a mingling of Pierre forms in the transition from one formation to the other. We are therefore fully warranted in concluding, as pointed out by Dawson long ago, that the Belly River series is of Niobrara age. The Eagle formation as named by Walter H. Weed includes about 200 feet of fresh-water sandstones overlying the leaden grey marine shales of the Colorado formation. In the sandstones plants occur that are similar to those found in the Canadian Belly River, which Dr. Knowlton afterward correlated with the Dunvegan group of Dr. Dawson as found in Canada. Dr. Stanton afterward added to the formation about a hundred feet of sandstones, shales, and lignitiferous beds from the upper part of which he says he collected marine invertebrates that showed a closer relation to the Montana than to the Colorado group. There is a possibility that some of the beds may have been wrongly identified; as Dr. Stanton says, "the formation has often been confused with several other horizons." However, the Eagle as originally defined, together with some of the immediately underlying calcareous and gypsiferous shales, marks the base of the Niobrara formation as indicated by the flora of the sandstones.

Apparently the entire series from the base of the Eagle sandstone to the base of the Pierre shales is a unit representing the Canadian Belly River formation, but it may be advisable to restrict the name Belly River to the soft badland shales at the summit and retain the name Eagle for the basal sandstones and their overlying shaly beds and possibly apply some other name (not Claggett) to the intervening beds.